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Coastal Shifts in Salmon Carrying Capacity

by

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Earlier work has shown that the production of salmon in coastal areas may be out of phase with salmon production in the open ocean (Ebbesmeyer et al. 1991, Beamish and Neville 1995). We are studying this possibility in the Strait of Georgia program. The objectives of the Strait of Georgia program are to relate the effects of climate change and climate variability on the marine survival and carrying capacity of Pacific salmon and associated species. The Strait of Georgia, located between the mainland and Vancouver Island, is an important marine ecosystem on Canada's west coast. Five species of Pacific salmon reside or pass through the Strait of Georgia with the majority of these from the Fraser River. Although pink and sockeye smolts may spend only a few weeks in the strait, coho and chinook salmon have historically remained for months and in many cases for their entire marine phase. Our preliminary results indicate that in recent years large numbers of chum salmon have been remaining in the strait through September and that chum abundance now exceeds the abundance of coho and chinook combined.

In the winter of 1976/77, a major shift in the ocean-atmospheric system occurred in the North Pacific. These large-scale ocean-atmospheric changes resulted in an intensification of the Aleutian Low, a drop in sea surface temperature (SST) in the central North Pacific and increase in SST in the eastern Pacific. Associated with these changes we identified changes in the Strait of Georgia including a trend of reduced discharge from the Fraser River and an increase in the bottom and surface water temperatures in the strait (Fig. 1). These climatic changes were associated

with major changes in the coho and chinook populations in the Strait of Georgia. Prior to the climatic change in 1976/77, chinook catches in the strait had been increasing steadily with maximum catches occurring from 1976 to 1978. Catches have since declined to approximately one quarter of the maximum levels. Associated with the decline in catch was a decline in the average marine survival of chinook salmon in the strait (Fig. 2) even though the number of chinook smolts entering the strait more than doubled the 1976 levels. We concluded that associated with the climatic changes there has been a change in carrying capacity for chinook salmon in the Strait of Georgia. This change in carrying capacity has contributed to the declines in abundance of the stocks and rebuilding stocks to the high abundance of the late 1970s is unlikely until the carrying capacity for chinook salmon changes.

Similar to chinook salmon, the survival of coho salmon has declined since 1976 (Fig. 3). Along with the decrease in survival was an increase in movement of coho out of the Strait of Georgia. Historically, the majority of coho originating from the streams and rivers around the strait have been caught within the strait. In recent years, there has been a trend for a larger percentage of coho from each brood year to move out of the strait (Fig 4.). The 1992 brood year (1995 catch year) may be the extreme of this trend with more than 90% of the coho leaving the strait.

We do not know what is causing this movement of coho out of the strait. We do know that the amount and annual change in Fraser River discharge can be

correlated to the production of coho and chinook salmon within the strait. Our studies have indicated that brood years of coho and chinook that went to sea in a year when Fraser River discharge was very high compared to the previous year were virtually always poor in relation to the previous years production. Similarly, brood years that went to sea when the Fraser River discharge was very low compared to the previous year almost never had lower production than the previous year.

In recent years this relationship between change in discharge and production in the Strait of Georgia has been complicated by a change in the timing and volume of the spring freshets. Since the late 1980s, the spring freshet has been occurring earlier in the year and even though total yearly discharge has decreased, the total April discharge has increased (Fig. 5). In addition, there appears to be further warming of the bottom and surface water in the strait during the 1990s. We suggest that these changes in Fraser River discharge and the apparent increase in the bottom and surface waters of the Strait of Georgia may indicate another climatic shift or change that differs in origin from the 1976/77 shift. Therefore, we have identified impacts of short-term or climate variability and long-term or climate change effects on the carrying capacity for salmon in the strait.

We are presently conducting a three year multidisciplinary study to examine the factors causing the movement of coho salmon out of the strait and the declines in chinook and coho survival and abundance in more detail. We will study the

abundance, diets, growth and behavior of coho and chinook salmon throughout their marine life history using a series of surveys conducted within the Strait of Georgia in addition to Queen Charlotte Strait, Juan de Fuca Strait and the west coast of Vancouver Island. In addition, data will be collected on the factors effecting the productivity and the timing of the production changes in the Fraser River plume and the Strait of Georgia. Samples of nutrients, phytoplankton and zooplankton will be collected weekly in and around the Fraser River plume, before, during and after the spring bloom. We will combine the physical and biological data collected during the study into a multidisciplinary model.

This model will consist of a physical circuation/mixing module with biological submodels, including nutrients through to larval fishes. The model should be capable of simulating in detail the spring freshet and the annual cycle. A second model will be developed for simulating past events in the Strait of Georgia that may have influenced strong and week year classes of coho and chinook salmon. This latter component will be combined with retroactive analysis of existing fisheries and oceanographic data to identify critical factors in the Strait of Georgia that have affected the survival of coho and chinook populations in the past. These models will assist us in understanding how climatic variations or changes are linked to the survival, and behavior of coho and chinook salmon. This information can be used to develop short-term and long-term harvest strategies and develop enhancement strategies that are consistent with the productive capacity of the Strait of Georgia.

Literature cited

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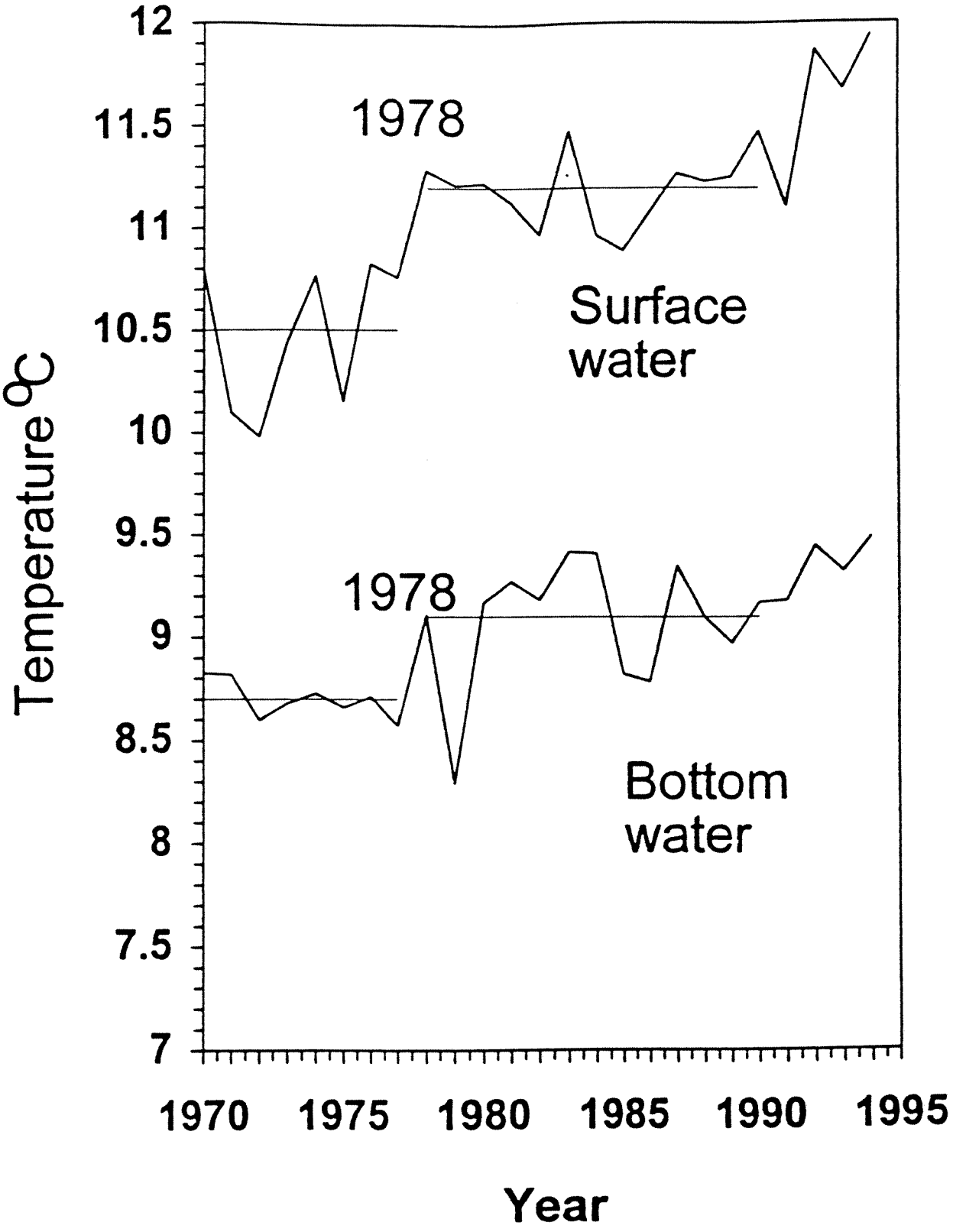
Figure 1. The average surface and bottom water temperatures in the Strait of Georgia showing the abrupt change in temperature in 1978. Note the increasing temperatures in the 1990s suggesting that a second shift in temperature may be occurring. Data are average daily values summarized by year.

Figure 2. Brood year survival of chinook salmon from the Strait of Georgia and Fraser River hatcheries. There was a dramatic decline in average survival between the period before and after 1977.

Figure 3. Brood year survival of coho salmon from the Strait of Georgia and Fraser River hatcheries. Note the period of declining survival following 1977.

Figure 4. Estimated movement of Strait of Georgia hatchery coho offshore. The number of coho originating from the Strait of Georgia but caught in areas outside the strait is expressed as a percent of the total catch of Strait of Georgia coho. The 1992 brood year (1995 catch year) value is preliminary.

Figure 5. Average daily discharge rate for April 1970 to 1994. The total April discharge has been increasing in recent years even though total annual discharge has been near historical lows.



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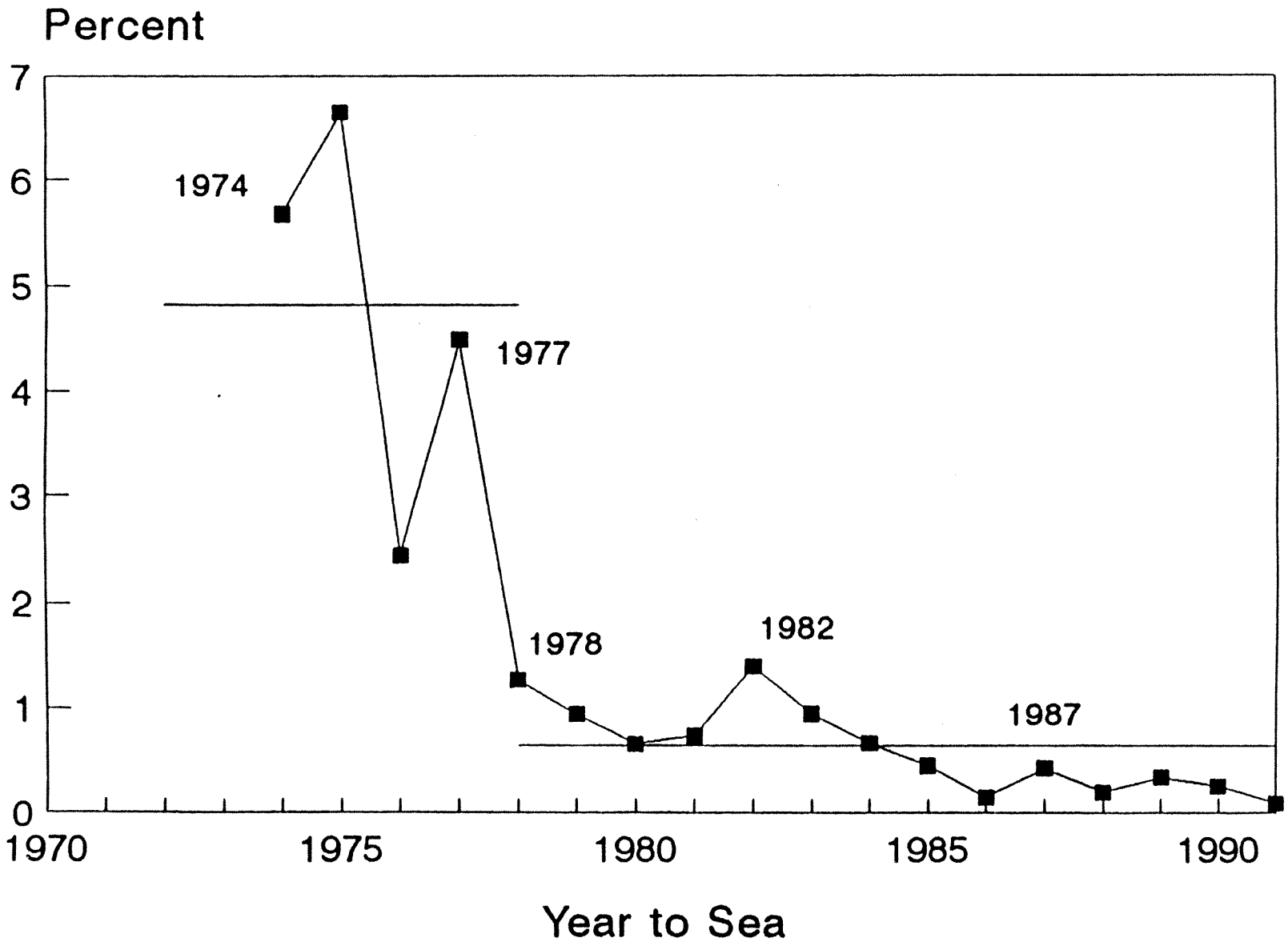

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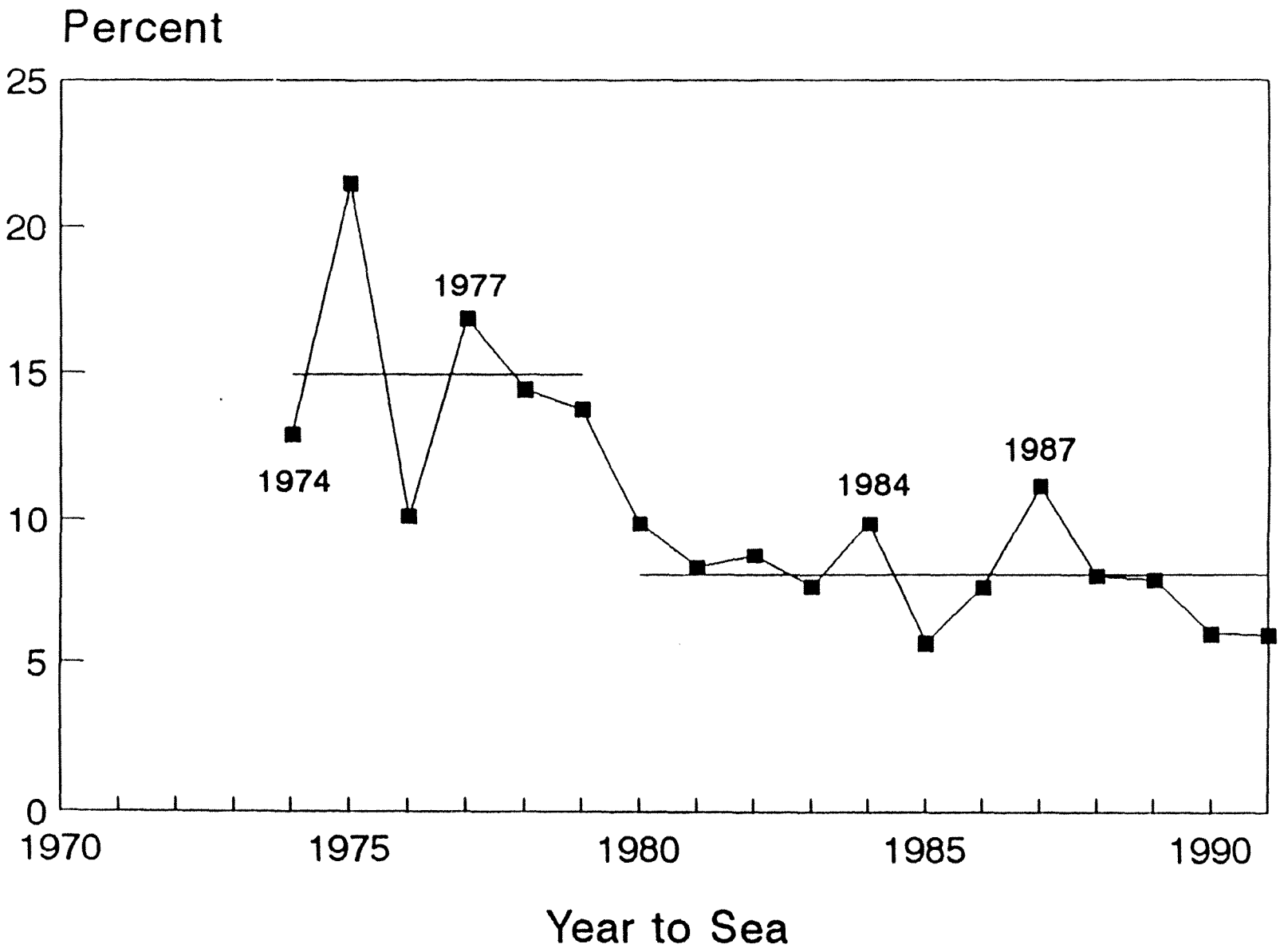

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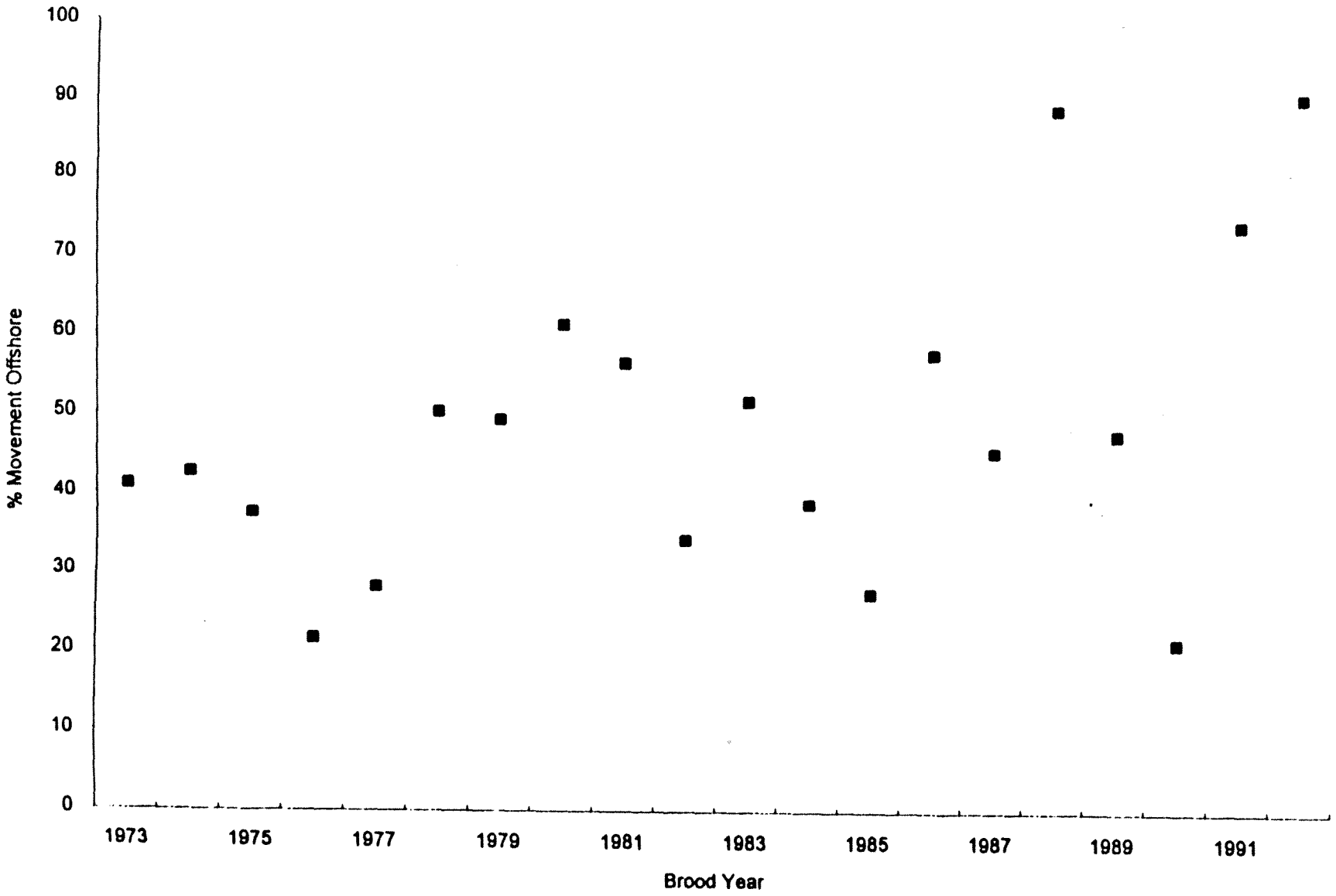

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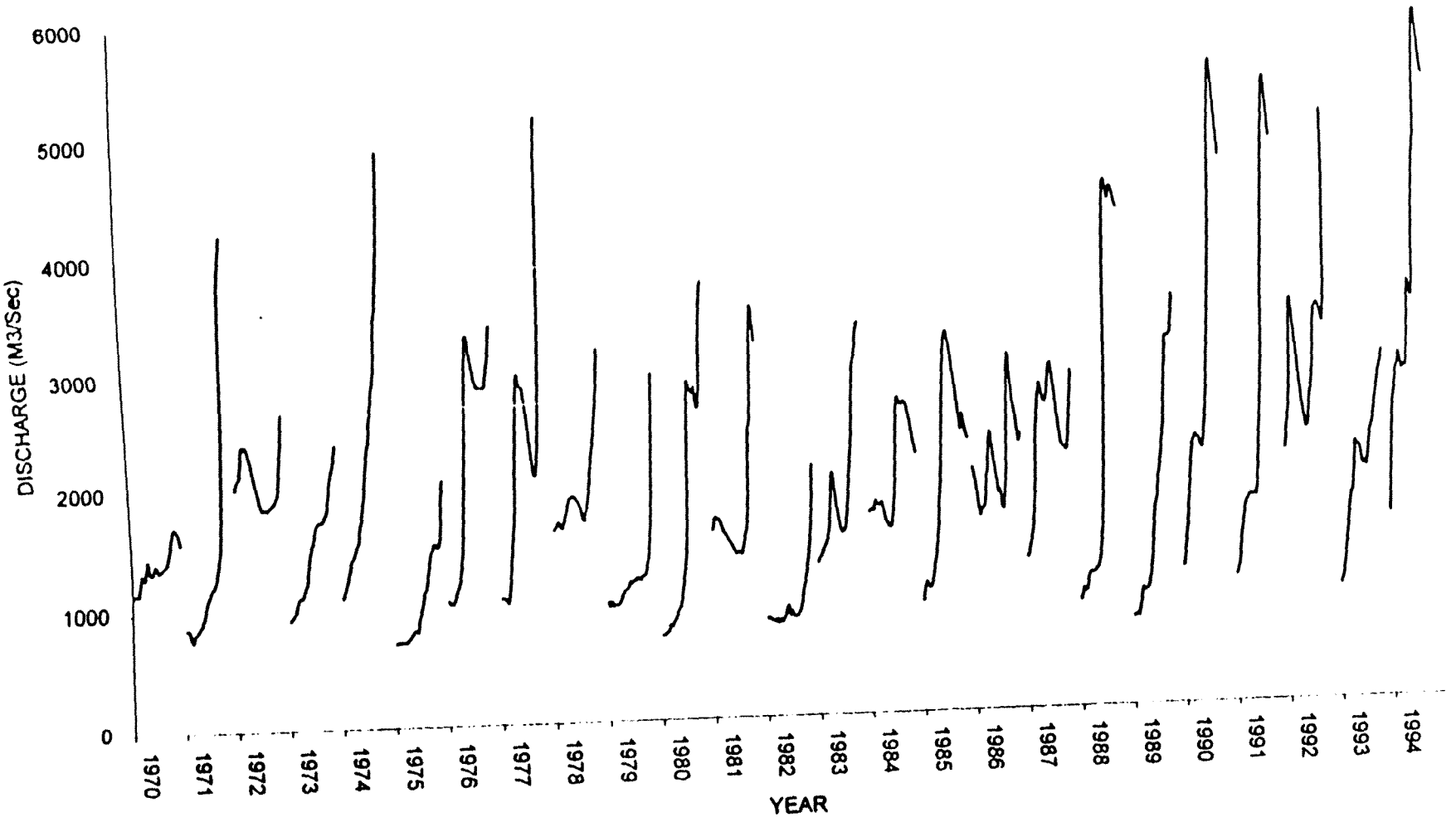

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